

# **Medication Errors in Adolescents using Asthma Controller Medications**

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## **Abstract**

### **Background/Introduction:**

Frequent medication errors have been observed in adult populations using inhaled asthma controller medications for respiratory diseases including asthma and COPD. These errors are associated with higher rate of exacerbations and decreased patient outcomes. Little research has been reported demonstrating medication errors in the adolescent asthma population. This study aims to bridge the gap in literature, demonstrating the number and types of errors adolescents and caregivers report regarding adolescent use of asthma controller medications.

### **Methods:**

Forty-six providers from four pediatric primary care practices in North Carolina participated in the study. Adolescents that met inclusion criteria were interviewed about their asthma controller medication use while caregivers were asked to complete a written questionnaire reporting knowledge of their adolescent's medication use. Inclusion criteria included: ages 11 to 17 years old, spoke and read English or Spanish, had persistent asthma, were present for an acute or follow-up asthma visit or a well-child visit, and had previously visited the clinic at least once for asthma. Answers reported by adolescents and caregivers were compared to the prescribed administration instructions in the adolescent's medical record. Discrepancies between reported use and prescribed instructions outlined in the adolescent's medical record were defined as an error. Descriptive and regression statistical analysis was applied to the dataset using IBM SPSS Statistics software.

### **Results:**

Three hundred and nineteen adolescents participated in the study. Thirty-eight percent of adolescents reported one error using asthma controller medications. Sixteen percent reported two

errors and 5% reported three or more errors. Forty-two percent of caregivers reported one error in adolescents using asthma controller medications. Fourteen percent reported two errors, while 6% reported three or more errors. The type of error most frequently reported by both adolescents and caregivers was not taking the medication at all, reported by 32% of adolescents and 29% of caregivers. The medication associated with the most reported errors was QVAR®, reported by 32% of adolescents and 31% of caregivers.

### **Conclusions:**

Both adolescents and caregivers commonly report errors in adolescent use of asthma controller medication. Providers and pharmacists can work to educate adolescent patients on asthma controller medication use to prevent medication errors.

### **Introduction**

An estimated 6 million children are diagnosed with asthma, making it one of the most common chronic illnesses among adolescents.<sup>1</sup> Asthma is characterized by chronic airway inflammation, leading to airflow obstruction and bronchial hyperresponsiveness.<sup>2</sup> This causes clinical symptoms including shortness of breath, chest tightness, coughing, wheezing, and difficulty breathing.<sup>2</sup> These asthma symptoms can have a large impact on the adolescent's quality of life by limiting school, social and physical activities.<sup>3</sup> Management of this chronic illness often requires repeated physician visits and is associated with increased emergency department visits.<sup>4</sup> Standard of care for patients with persistent asthma includes long term control medications that reduce airway inflammation, relieve symptoms and prevent exacerbations.<sup>3,5</sup> According to the National Heart, Lung, and Blood Institute asthma practice guidelines, the preferred treatment for persistent asthma consists of low dose inhaled corticosteroids (ICS), with step up therapy increasing ICS dose or adding additional agents (long acting beta agonist,

montelukast, or oral corticosteroids). Oral tablets including cromolyn or montelukast can be used as alternative treatment.<sup>1,5</sup>

Caregiver involvement has been studied in adolescent populations, with increased involvement associated with better patient outcomes.<sup>6</sup> Excessive self-care autonomy at inappropriate ages of adolescent patients has also been associated with decreased medication adherence in the adolescent population.<sup>7</sup> This work has been translated directly to the adolescent asthma population, with increased ED visits in adolescents with caregivers suffering from psychological health illnesses such as depression.<sup>8</sup> By analyzing both adolescent self-reported medication use and caregiver reporting, this study aims to provide more depth on caregiver involvement in adolescent asthma management.

Medication errors can be defined as preventable events that lead to inappropriate medication use.<sup>9</sup> These errors are highly prevalent among the adolescent population in a variety of medication classes.<sup>10,11</sup> Previous research focuses on over-the-counter acetaminophen and chemotherapy medication, leading to toxicity and hospitalization of this population.<sup>10-14</sup> However, little research has been performed regarding the types of errors that adolescents make in using asthma controller medications.

Previous research has studied the misuse of inhalers in the adult COPD and asthma populations. A cross-sectional study analyzing errors in the outpatient respiratory care setting found at least one incorrect step in 48.2% of patient inhalation demonstrations while using COPD controller inhalers.<sup>15</sup> Melani, et al. analyzed medication errors associated with controller inhalers in both adult COPD and asthma populations, finding errors in metered dose inhalers (MDI), dry powder inhalers (DPI), and Turbohalers (12%, 35%, and 44%, respectively).<sup>16</sup> A study in the European Respiratory Journal found similar results in the adult COPD population,

with < 40% of patients able to perform appropriate inhalation technique compared to package insert instructions leading to increased exacerbations in past 3 months.<sup>17</sup> Despite the extensive body of research reporting medication errors in the adult asthma and COPD population, there is a lack of evidence in medication errors in regard to the pediatric asthma population. This study aims to bridge the gap in literature and determine the number and types of medication errors in the adolescent asthma population.

## **Methods**

### **Study Population**

Forty-six providers from four pediatric primary care practices in North Carolina agreed to participate in the study. The primary care practices included one academic practice and three private practices. The principal investigator visited each clinic to obtain written provider consent. Participants in the study were enrolled from June 2015 to November 2016. Staff from each practice explained the study to families attending the primary care practice for asthma management in adolescent patients. Families interested in the study were then referred to a research assistant to learn more. Research assistants explained the study to families during the pre-visit wait time where they obtained adolescent assent and caregiver consent and completed HIPAA forms. Research assistants then administered eligibility screeners for the study.

Adolescents were eligible if they met the following inclusion criteria: ages 11 to 17 years old, spoke and read English or Spanish, had persistent asthma, were present for an acute or follow-up asthma visit or a well-child visit, and had previously visited the clinic at least once for asthma. Persistent asthma was defined using the National Health Lung and Blood Institute Guidelines – experiencing asthma-related daytime symptoms more than twice a week, asthma-related nighttime symptoms more than twice a month or receiving one or more long-term

controller therapies for asthma.<sup>1</sup> Caregivers were eligible if they were greater than 18 years of age, spoke and read English or Spanish, and were legal guardian of the adolescent.

Four hundred and sixty-nine adolescents were initially screened for study inclusion. Out of these 469, 319 were on controller medications reported in their medical records and met inclusion criteria. Controller asthma medications included: Montelukast, QVAR Redihaler®, ProAir® HFA, Proventil® HFA, Ventolin® HFA, Advair, Symbicort®, Xopenex® HFA, and Pulmicort Flexhaler®. Adolescents and caregivers were both provided \$25 for their time.

### **Adolescent and Caregiver Reported Errors**

Adolescents were interviewed for the study after meeting with their primary care provider. In the interview, adolescents were asked the following questions regarding the use of their asthma controller medications:

- Medication name?
- How many days did you (adolescent) use it in the past week?
- How many times per day did you (adolescent) use it?
- How many pills or puffs did you (adolescent) use each time?
- How many times did you (adolescent) miss taking it?
- How well does the medicine work for you (adolescent)?

Caregivers were asked to complete a written questionnaire with the same questions regarding their adolescent's medication use stated above. Information from the adolescent interviews and caregiver questionnaire was extracted and compared to the adolescent's medical record. Medication errors were defined by analyzing discrepancies in reported adolescent use compared to prescribed medication administration instructions (Table 2).

## **Medical Record Extraction**

Each adolescent's medical record had information abstracted by the research assistant twelve months before the baseline visit. Information extracted from the medical record included the intended administration schedule of each prescribed asthma controller medication. All medications prescribed for asthma control use were extracted and included in the study. Any additional medication not prescribed for asthma diagnosis was omitted. Adolescent age was extracted from the medical record.

## **Patient Sociodemographic Factors**

Caregivers were asked a variety of questions regarding sociodemographic factors of the adolescent, caregiver and household, including primary language spoken at home, race, total annual household income, and adolescent's health insurance type.

Adolescent age was extracted from medical record and measured as continuous variable. Adolescent and caregiver gender was measured as dichotomous variable. Languages spoken at home were measured as a dichotomous variable (English or Spanish). Adolescent race/ethnicity was organized as five categories: white, African American, native American/American Indian, Hispanic, other. Caregiver race was measured by dichotomous variable (white or non-white). Total self-reported household income was categorized into 6 categories: less than \$10,000, \$10,000-\$19,999, \$20,000-\$29,999, \$30,000-\$49,999, \$50,000-\$69,999 and \$70,000 or more. Type of health insurance was measured as dichotomous variable (Medicaid or other). Asthma severity was measured as dichotomous variable, classified as mild persistent vs moderate/severe persistent according to National Heart Lung and Blood Institute's guidelines.<sup>1</sup>

## **Data Analysis**

All analyses were conducted using IBM SPSS Statistics. Descriptive statistics were computed for the number and types of errors that were reported by both adolescents and caregivers. Descriptive statistics were computed for the adolescent and caregiver sociodemographic characteristics were imported from an existing dataset. Multivariable regression was utilized to predict whether sociodemographic factors were associated with adolescents and caregivers reporting one or more errors in using asthma controller medication.

## **Results**

Table 1 demonstrates the youth and caregiver demographic characteristics. Fifty-seven of patients were male. The average adolescent age was 13.2 years old (SD 1.9) and ranged from 11 to 17 years old. Thirty-six percent of adolescents were Caucasian, 37.2% African American, 13% Hispanic, 11% Native American. Ninety-one percent of adolescents reported English as their primary language at home, while nine percent reported Spanish.

Table 2 demonstrates the typology of errors created comparing reported use to administration instructions as prescribed in the adolescent's medical record. Errors included: extra single administration doses, too few single administration doses, taking too frequently per day, not taking enough times per day, missing 1-3 doses per week, missing 3+ doses per week, not taking at all, or does not know names of all medication.

Table 3 demonstrates the number of errors detected for adolescents and caregivers by comparing their reported medication use to the medication directions in the medical record. Many errors were detected for both adolescents and caregivers, 58% and 61% respectively. Thirty-eight percent of adolescents reported one error, 16% reported two errors, 5% reported



three or more errors. Forty-two percent of caregivers reported one error, 14% reported two errors, 6% reported three or more errors.

Table 4 demonstrates the types of errors reported by adolescents and caregivers. The three most commonly reported errors by adolescents were not making the medication at all, missing three or more doses per week, and not taking the medication enough times per day. Thirty-two percent of adolescents reported not taking the medication at all. Fifteen percent of adolescents reported missing three or more doses per week. Ten percent of patients reported not taking the medication enough times per day. The three most commonly reported errors by caregivers were not taking the medication at all, missing three or more doses per week, and missing 1-3 doses per week. Twenty-nine percent of caregivers reported the adolescent not taking the medication at all. Fourteen percent of caregivers reported missing three or more doses per week. Nine percent of caregivers reported missing 1-3 doses per week. The most commonly reported errors for both adolescents and caregivers was not taking the medication at all and missing three or more doses per week. The least commonly reported for both adolescents and caregivers was taking doses too frequently per day, 4% and 3% respectively.

Table 5 demonstrates the number of errors associated with each type of controller medication. Thirty-two percent of adolescents reported errors associated with QVAR Redihaler®, use, the highest amount across each type of controller medications. Thirteen percent reported errors with Flovent® HFA, while 12% of adolescents reported errors with Montelukast. The three medications with the highest number of errors reported by caregivers were QVAR Redihaler®, Flovent® HFA, and Advair with 31%, 13%, and 11%, respectively.

## **Discussion**

Caregivers were more likely to report errors than adolescents (61.4% caregivers vs 58% adolescents). When adolescents and caregivers do report errors, the most common reported error across both groups is not taking the medication at all. The second most commonly reported errors was missing three or more doses per week. No significant discrepancies in medication error reporting was observed between adolescent and caregiver answers. These findings demonstrate that although slight deviations may occur, adolescents and caregivers are generally consistent in their involvement in the adolescent's asthma controller medication use. Both caregivers and adolescents reported the most medication errors with QVAR Redihaler®, (32% adolescents, 31% caregivers) with Flovent being second medication with the most errors (13% adolescents, 13% caregivers).

Previous research has analyzed medication errors in the adolescent cancer population. Walsh et al., reported 17% of patients reported non-adherence in the adolescent population, while 13% of patients reported missing doses in the last 7 days for any medicine used in the cancer treatment, both chemotherapy and supportive meds.<sup>10</sup> Similar to asthma controller medication, chemotherapy and supportive meds may have difficult administration techniques and instructions for adolescents. This creates opportunity for both adolescents and caregivers to misinterpret appropriate administration schedule and/or instructions, leading to errors in the population. Our study found similar information in regard to the errors that were reported. Medications that had strict administration schedule had more errors reported than as needed medication.

Another clinical area that has research regarding the number and types of errors that are performed is over the counter medications. Due to high availability and use in the adolescent

population, these medications are associated with high risks of medication errors. Alander et al., studied medication errors in regard to over-the-counter acetaminophen. In this study, 3% of errors were identified as unintentional dosing errors due to either excess medication self-medicated by the adolescent or provided unintentionally by the caregiver.<sup>13</sup> We found that both adolescents and caregivers were likely to report medication errors when using the medication, demonstrating the clinical need for both adolescent patients and caregivers to be educated in regard to correct medication use.

There is a current gap in knowledge regarding misuse of medications in the adolescent population, particularly in using asthma controller medications. The results of this study can be used to improve the communication between physicians and patients regarding using asthma controller medications. By learning the types of errors that adolescents and caregivers make, physicians can address relevant concerns in follow up visits regarding chronic asthma management. Physicians can utilize this information to ensure that both adolescent patients and caregivers are appropriately educated on asthma controller medications in order to decrease unnecessary follow up visits and improve patient outcomes.

The pharmacist's role in healthcare includes providing patients with information to take their medications appropriately. Utilizing this information, pharmacists in the community setting will be able to cater their patient education in order to maximize patient care in the adolescent asthma population. Emphasizing the importance of adherence in the adolescent patient population while using scheduled controller medication can decrease need for rescue inhalers.

There are various limitations that exist within this study. One limitation is that providers may not accurately report how patients should be using the medication in the medical record or may not update the medical record as instructions change for the patient over time. This may

falsely increase the number of errors reported when comparing patient use to an incorrect medical record. The patients included in this study were attending pediatric clinics instead of specifically pulmonology clinics, which may have limited generalizability to those with severe asthma diagnosis. The patients in this study were only in North Carolina, which may not be representative of the entire U.S. adolescent population. The adolescent and caregiver reports may not assess all types of errors (incorrect spacer use, incorrect inhalation technique, etc) which is a limitation in our study. Despite the limitations, the study plays a key role in improve the communication that both physicians and pharmacists have with adolescents in regard to their asthma controller medications.

Future research can be performed to assess provider and pharmacist interventions in reducing the amount of medication errors adolescents report regarding asthma controller use. A future study idea is to analyze number and types of errors reported before and after pharmacist counseling interventions on the adolescent asthma population. This analysis may can the impact of community pharmacists to reduce the amount of medication errors this patient population. Providers can utilize this information when establishing routine care with pediatric asthma patients to ensure appropriate adherence and reduce medication errors.

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SD provided oversight during data analysis methods and statistic use. DMC was an investigator for the original study, contributed to the development of this study, and critically edited the manuscript. BLS conceived the study, oversaw the collection, analysis, and interpretation of data, and edited the manuscript critically.

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### ***Conflicts of Interest***

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the article.

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**Table 1: Youth and caregiver demographic and youth asthma-related characteristics (N=359)**

<b>Characteristics</b>	<b>Percent (N)</b>
<b>Youth Gender</b>	
Male	57.1 (205)
Female	42.9 (154)
<b>Youth Race/Ethnicity</b>	
Caucasian	36.2 (130)
African American	37.2 (134)
Hispanic	12.5 (45)
Native American	11.4 (41)
Other	2.5 (9)
<b>Asthma Severity</b>	
Mild	46.8 (168)
Moderate/Severe	53.2 (191)
<b>Caregiver Gender</b>	
Male	13.6 (49)
Female	86.4 (310)
<b>Caregiver Race</b>	
Caucasian	46.0 (165)
Non-Caucasian	54.0 (194)
<b>On Controller Medication</b>	
Yes	88.9 (319)
No	11.1 (40)
<b>Primary Language Spoken at Home</b>	
English	91.5 (292)
Spanish	8.5 (27)
<b>Reason For Visit</b>	
Asthma	66.6 (239)
Other	33.4 (12)
<b>Household Total Annual Income</b>	
Less than \$10,000	16.4 (59)
\$10,000-\$19,999	15.3 (55)
\$20,000-\$29,999	18.7 (67)
\$30,000-\$49,999	13.1 (47)
\$50,000-\$69,999	13.1 (47)
\$70,000 or more	23.4 (84)
<b>Has Medicaid as Health Insurance</b>	
Yes	54.6 (196)
No	45.4 (163)
	<b>Mean (SD), Range</b>
<b>Youth Age</b>	13.2 (1.9), 11-17
<b>Years Living with Asthma</b>	9.5 (4.1), 1-17
<b>Caregiver Age</b>	42.6 (8.6), 19-76
<b>Caregiver Education (in years)</b>	13.6 (3.3), 4-26

**Table 2: Typology of Errors**

<b>Type of Error</b>	<b>Error Definition</b>
Extra single administration doses	Two puffs (or more) instead of one puff per administration
Too few single administration doses	One puff instead of two puffs per administration
Taking too frequently per day	Twice daily (or more) administration instead of prescribed once daily administration
Not taking enough times per day	Once daily administration instead of prescribed twice daily administration
Missing 1-3 doses per week	Missing less than three doses in a seven-day period
Missing three or more doses per week	Missing more than three doses in a seven-day period
Not taking at all	Does not report taking medication although listed on medical record
Does not know names of all medication	Reports medication with descriptive factors instead of name (i.e red inhaler, tablet, etc)

**Table 3: Number of Errors Reported by Adolescents and Caregivers (N=319)**

<b>Reported Errors</b>	<b>Adolescents Reporting Errors Percent (N = 319)</b>	<b>Caregivers Reporting Errors Percent (N = 319)</b>
0	42.0 (134)	38.6 (123)
1	37.6 (120)	41.7 (133)
2	157.7 (50)	13.5 (43)
3+	4.70 (15)	6.26 (20)

**Table 4: Types of Errors Reported by Adolescents and Caregivers (N=319)**

<b>Error Type</b>	<b>Adolescent Reporting Errors: Percent (N)</b>	<b>Caregiver Reporting Errors Percent: Percent (N)</b>
Not Taking At All	31.9 (102)	28.8 (92)
Missing 3+ Doses Per Week	15.4 (49)	14.4 (46)
Not Taking Enough Times Per Day	9.40 (30)	7.52 (24)
Missing 1-3 Doses Per Week	8.77 (28)	9.09 (29)
Does Not Know Names of All Medication	8.77 (28)	6.58 (21)
Too Few Single Administration Doses	3.76 (12)	5.64 (18)
Extra Single Administration Doses	3.13 (10)	4.07 (13)
Taking Too Frequently Per Day	2.50 (8)	3.45 (11)



**Table 5: Number of Errors Reported for Each Controller Medication (N=319)**

	<b>Adolescent Reported Errors Percent (N)</b>	<b>Caregiver Reported Errors Percent (N)</b>
QVAR® RediHaler	32.3 (103)	30.7 (98)
Flovent® HFA	12.5 (40)	12.5 (40)
Montelukast	12.2 (39)	9.7 (31)
Advair	11.9 (38)	11.0 (35)
Proair® HFA	2.8 (9)	2.8 (9)
Ventolin® HFA	1.9 (6)	2.8 (9)
Pulmicort® Flexhaler	1.3 (4)	0.9 (3)
Proventil® HFA	0.6 (2)	0.6 (2)
Symbicort®	0.6 (2)	0.3 (1)
Xopenex® HFA	0.3 (1)	0 (0)